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SPECIFICATIONS

FOR

STEAM MACHINERY

OF

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(1500 TONS.)

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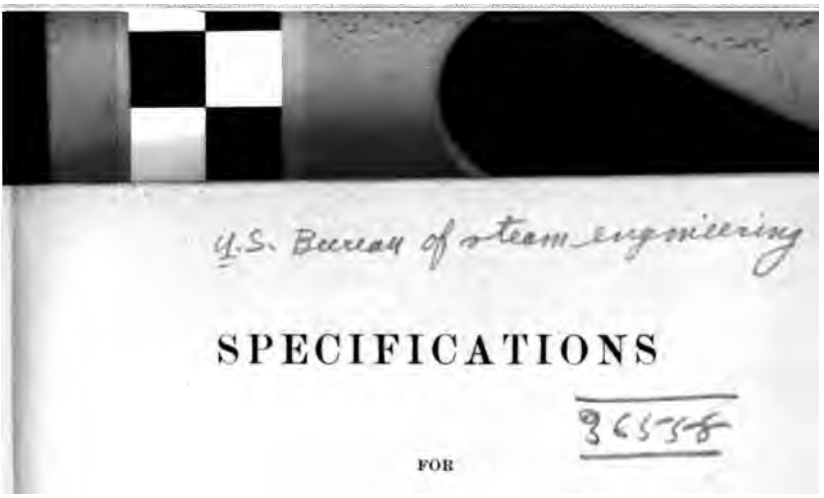

U.S. Bureau of steam engineering

SPECIFICATIONS

36538

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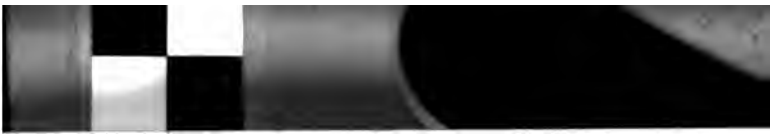


SPECIFICATIONS

FOR A

TWO-CYLINDER COMPOUND, VERTICAL, DIRECT-ACTING SCREW ENGINE, OF 2300 INDICATED HORSE-POWER.

GENERAL DESCRIPTION.

The engine is to have—

One (1) high-pressure cylinder of 42 inches diameter, and one (1) low-pressure cylinder of 78 inches diameter, having 48 inches stroke of piston.

The cylinders are to be placed directly over the crank-shaft; each cylinder being supported by two wrought-iron columns, which are secured to the engine bed-plate, and by two cast-iron brackets, which form at the same time the crosshead guides and are secured to the condenser.

Each cylinder is to be made with a double shell, inclosing, in the case of the high-pressure cylinder, the receiver, and, in the case of the low-pressure cylinder, the steam-passage leading from the receiver to the steam-chest on one side, and the exhaust-passage leading directly to the condenser on the other side. The total capacity of the receiver is to be about one and a half times the capacity of the high-pressure cylinder.

Each cylinder is to have an inner wearing-cylinder

cast separately, which, when secured in place, is to be surrounded by a jacket space which may be filled with steam from the boilers.

The valve-chests are to be placed on the forward side of the high-pressure cylinder and on the after side of the low-pressure cylinder.

Each cylinder is to have a main slide-valve and a cut-off valve. The main slide-valves are to be double-ported and worked by means of eccentrics and links coupled directly to the valve stems. The weight of each valve is to be counterbalanced by a piston working in a cylinder placed on the top of the steam-chest. [*See Addenda, No. 4.*]

The cut-off valves are to slide on the back of the main slide-valves and to be adjustable, while the engine is in motion, to cut off between the limits of $\frac{1}{4}$ and $\frac{5}{8}$ of the stroke of piston of the high-pressure cylinder, and of $\frac{1}{3}$ and $\frac{3}{8}$ of the stroke of piston of the low-pressure cylinder. They are to be operated by separate eccentrics coupled directly to the stems.

Each cylinder is to have one piston-rod, at the lower end of which the cross-head journal and the gibs for the cross-head guides are fitted.

The connecting rods are to have a length of 9 feet between centers of journals. The upper end of each rod is to be forked with solid eyes in which the cross-head pin is fixed. The crank-pin journal is to be fitted with brasses, caps, and bolts.

The crank-shaft is to be "built up" and to have two cranks at right angles to each other; the forward or high-pressure cylinder crank being the leading one. Counterbalances are to be forged directly to the cranks. The

crank-shaft is to be mounted on four journals having an aggregate length of 84 inches, and it is to be connected with the line-shafting by a disengaging coupling.

The crank-shaft pillow-blocks are to be made in one casting, forming the bed-plate of the engine, to which the columns supporting the cylinders and the brackets supporting the condenser are to be secured, and which is to be bolted directly to the engine frames forming a part of the hull of the vessel.

There is to be one surface condenser having an aggregate cooling surface of 4,500 square feet. The tubes are to be placed athwartships and so arranged as to be readily withdrawn and replaced. The refrigerating water, entering on the starboard side of the vessel, is to pass through the lower half and return through the upper half of the tubes, to be discharged through the outboard delivery-valve on the starboard side of the vessel. The condenser is to be supported at each end by two brackets secured to the engine bed-plate.

The condenser is to be placed at the center of engines below the cylinders, at such a height as to leave the center main bearings accessible for examination and adjustment, and allow the shaft to be removed. To each side of the condenser are secured the brackets which support the cylinders. The exhaust nozzle of the low-pressure cylinder is to be bolted directly to the top of the condenser.

The air-pump, circulating-pump, and feed-pumps are to be independent of the main engines. There is to be one (1) horizontal double-acting air-pump, and one (1) horizontal double-acting circulating-pump, both worked directly from the piston of a steam cylinder placed between the two

pumps. The circulating-pump must be capable of discharging 3,300 gallons of water when working at a piston speed of 120 feet per minute.

There are to be two (2) single-acting feed-pumps, secured to the sides of the steam cylinder, and worked from the cross-head of the circulating-pump. [*See Addenda, No. 1.*]

These pumps are to be placed in a fore-and-aft direction on the starboard side of the vessel, leaving a passage-way of not less than 30 inches between them and the main engines.

The total length of the combined pumps is not to exceed 15 feet 6½ inches over the faces of the outside flanges of the pump cylinders.

There are to be two bilge-pumps worked by an eccentric placed on the crank-shaft directly abaft the after main bearing. The bilge-pumps are to be single-acting plunger pumps, so arranged as to be thrown readily in and out of gear while the engine is in motion; they are to discharge the water into an outboard-delivery valve chamber on the port side of the vessel.

The steam reversing gear is to be placed on the port side of the engines. It is to consist of a steam cylinder bolted to the side of the condenser, the piston of which is to act by means of a link upon an arm of the reversing shaft, which is connected by means of arms and suspension rods with the links of the main slide-valves. The valve of the starting cylinder is to be operated by a hand lever from the platform on the starboard side of the engine.

The hand reversing gear is to be arranged so as to be readily thrown in and out of gear. It is to be placed on the starboard side of the engine, and to consist of a hand-

wheel and screw gear operating a shaft which is connected by an arm and link with the after arm of the main reversing shaft.

There is to be a gallery running all around the engines on a level with the berth deck. The various valves, levers, and gears for working, regulating, and adjusting the main engines are to be operated from this gallery on the starboard side.

There is also to be an upper gallery on a level with the spar-deck. Ladders are to be provided to establish communication between these galleries and the lower engine-room floor. Passage ways of sufficient width must be left all around the engines on the galleries and on the lower engine-room floor.

There will be a collar-thrust bearing located immediately abaft the clutch coupling.

The propeller shaft will be cased with a composition sleeve and will run on lignumvitæ bearings.

The screw propeller is to have four adjustable blades, a diameter of 14 feet 3 inches and a mean pitch of 21 feet 4 inches.

Height of center of shaft above base-line of vessel at after end of stern-post	5 ft. 9 ins
Height of center of shaft above base-line of vessel at center of engines	5 ft. 1½ ins.
Height of face of cylinder-head flanges above axis of shaft	19 ft. 3½ ins.
Distance from after side of stern-post to center of engines	86 ft. 11 ins.
Extreme length of engines over valve-chest covers	18 ft. 2 ins.
Extreme width of engines over cylinder casings	8 ft. 9 ins.

The boilers are to be cylindrical, braced for a working pressure of 100 pounds per square inch above the atmosphere. They are to have an aggregate grate surface of 270 square feet and an aggregate water-heating surface of about 6,600 square feet. They are to have internal cylindrical furnaces and horizontal fire-tubes returning above the furnaces. Each furnace is to have separate back and front connections, the latter being provided with a damper.

There will be two single-end and two double-end boilers. The single-end boilers will have a diameter of 11 feet and a length of 9 feet 6 inches and contain two furnaces each. The double-end boilers will have a diameter of 11 feet and a length of 18 feet 3 inches and contain four furnaces each. The boilers will be placed with their longitudinal axis in the fore-and-aft direction of the vessel, the single-end boilers aft fronting the double-end boilers, with a fire-room 9 feet 6 inches long between them. At the forward end of the double-end boilers there will be a fire-room 9 feet long. On the starboard side there will be a passage way between the two fire-rooms and the engine-room.

There will be a vertical steam-drum 7 feet 6 inches in diameter and 8 feet 6 inches high, traversed by six flues 18 inches in diameter, and surrounded by the uptake.

The smoke-pipe will be stationary, 7 feet 3 inches in diameter and 60 feet high above the level of the grates.

Provision is to be made for closing the fire-room hatches and other openings sufficiently tight to maintain an air-pressure equivalent to a head of water of 1 inch in the fire-rooms.

There will be two Sturtevant blowers in the after fire-room, drawing the air directly from the engine-room and

from a duct leading to the after part of the berth-deck, respectively; and one Sturtevant blower in the forward fire-room, taking the air from the forward part of the berth-deck. Each blower is to be capable of discharging 12,000 cubic feet of air per minute under a head of 1 inch of water at the discharge opening. The air is to be delivered directly into the fire-room. Each blower is to be driven by a separate direct-acting engine coupled to the shaft of the fan.

There is to be one (1) horizontal Blake steam-pump, having a water piston 6 inches in diameter and 12 inches stroke, placed in the after fire-room on the port side. This pump is to be fitted for feeding and pumping out the boilers and for fire-apparatus.

There is to be a Baird distiller of 2,000 gallons capacity per day, with tank, filter, and separate steam-pump, placed on a platform in the forward fire-room.

There will be two horizontal Blake steam-pumps, each capable of delivering 1,000 gallons of water per minute, connected for pumping out the water-tight compartments, and also connected with sea-valves and fire-apparatus. One of these pumps is to be placed on a platform in the forward fire-room, and the other is to be placed at the after end of engine-room on the port side.

There is to be an ash-hoisting engine fitted for each fire-room, and suitable arrangements are to be made for dumping the ashes on the spar-deck.

Two steam syphon-pumps with bilge connections are to be fitted—one in engine-room and one in after fire-room.

DETAILED DESCRIPTION OF ENGINES.

Cylinders.—Each cylinder is to consist of an outer casing and an inner wearing-cylinder, cast separately.

The high-pressure and low-pressure cylinder casings are to be secured together with wrought-iron bolts, $1\frac{1}{4}$ inches in diameter, and spaced not over $5\frac{1}{2}$ inches apart, passing through faced flanges not less than 2 inches thick and $4\frac{1}{2}$ inches wide.

Distance between axes of cylinders to be 80 inches.

The *cylinder heads* are to be cast with a double shell properly stiffened by ribs. Each head is to have holes bored of suitable size, and with the proper facings for the relief-valve and for the piston-rod stuffing-box. The cylinder heads are to be fitted with pipes and valves for admitting steam to the interior and for draining off the water of condensation.

The *inner wearing-cylinders* are to be made of the best cold-blast iron, cast as hard as can be worked by tools; smoothly bored to a diameter of 42 inches in the case of the high-pressure cylinder, and to a diameter of 78 inches in the case of the low-pressure cylinder, and of a length suitable for a stroke of 48 inches with a clearance of $\frac{7}{16}$ inch at the upper end, and $\frac{9}{16}$ inch at the lower end of the cylinders.

The wearing cylinders and outer cylinder-casings are to be accurately turned and bored at the ends to fit each other steam-tight. There is to be an annular space, not less than 1 inch wide and 42 inches long, surrounding each wearing cylinder, which is to form a steam-jacket and is to be fitted with suitable steam and drainage pipes and valves. The wearing cylinder is to be secured in such a manner as to make sufficient allowance for difference of expansion, and provision is to be made for packing the joint at the upper end steam-tight.

The *cylinder covers* are to be cast with a double shell, properly ribbed. They are to have faced flanges not less than 2 inches thick and 4¾ inches wide, and are to be secured in place with wrought-iron standing bolts 1⅜ inches in diameter, spaced not over 5½ inches apart and having finished wrought-iron nuts. In the center of each cylinder cover is to be a man-hole 24 inches in diameter, closed by a cover with double shell and finished on the outside, secured by standing bolts with finished wrought-iron nuts.

The man-hole cover is to have a stuffing-box fitted with metallic packing of approved design for the upper end of the piston-rod; and a finished brass cover inclosing the piston-rod is to be bolted to the man-hole cover with finished composition nuts.

Each cover is to have a hole bored of suitable size and with the proper facings for the relief-valve. The cylinder covers are to be fitted with pipes and valves for admitting steam to the interior and for drawing off the water of condensation.

Automatic relief-valves of an approved pattern, each having an opening not less than 15 inches in area, are to be fitted to each cylinder, one at the top and one at the bottom. They are to be fitted with finished brass covers and are to discharge through suitable brass or copper pipes into the hot-well.

A starting valve is to be provided for each cylinder. The valves are to be of brass and to be operated by wrought-iron handles on the working platform on the starboard side of the engines. The openings of ports and pipes to be not less than 9 square inches. All the working gear of these valves is to be finished.

Arrangements are also to be made for passing the steam directly from the boilers into the low-pressure steam-chest, and also for exhausting the steam directly from the low-pressure cylinder into the atmosphere.

The *bosses* for supporting columns are to be 8 inches in diameter and 8 inches long, substantially united to cylinder castings by ribs.

The *steam-ports* of the high-pressure cylinder are to be double, 28 inches long and $2\frac{1}{2}$ inches wide.

The *steam-ports* of the low-pressure cylinder are to be double, 68 inches long and $3\frac{1}{2}$ inches wide.

The *valve-seats* are to be cast separately, of the very best iron, as hard as can be worked. They are to be secured in place with countersunk composition screws.

The *valve-chests* are to be cast of the best iron. They are to be secured to the cylinders by wrought-iron bolts $1\frac{1}{4}$ inches in diameter with wrought-iron nuts, and spaced not over $5\frac{1}{2}$ inches apart, and passing through faced flanges not less than $1\frac{3}{4}$ inches thick and $4\frac{1}{2}$ inches wide.

The *stuffing-boxes* for the main and cut-off valve stems are to be cast on the chests. They are to have brass bushings, and followers with a provision for catching the drip. The packing spaces to be fitted with Katzenstein's metallic packing.

The *chest covers* are to be made with a double shell well ribbed. The flanges are to be faced and finished on the outside. They are to be secured by wrought-iron bolts with finished wrought-iron nuts.

Each steam-chest is to have on each side two hand-holes with facings for flanges, one at the top and one at the bottom, placed so that the steam-ports may be examined

through them. Covers to be of cast-iron, finished on the outside, and secured by finished wrought-iron nuts.

Each steam-chest is to be provided on its upper side with openings and faced flanges for securing the covers and guides for the cut-off valve stems and the balancing cylinders of the main slide valves.

The *covers for the cut-off valve stems* are to be of brass, finished all over.

The *balancing cylinders* of the main slide valves are to be of cast-iron, accurately bored, and provided with a finished dome-shaped cover. The balancing pistons are to have cast-iron packing rings, and are to fit steam-tight within the cylinders. The cylinders are to be open to the steam-chest below, and the top is to be connected by means of a finished brass or copper pipe with the vacuum chamber of the condenser. The diameter of the balancing cylinder on the high-pressure steam-chest is to be 6 inches, and the diameter of the balancing cylinder on the low-pressure steam-chest is to be 12 inches.

At the lower end of the high-pressure steam-chest, on the port side, there is to be a circular opening of 13 inches diameter, having a faced flange of suitable size for the steam stop-valve.

The *piston-rod stuffing-boxes* are to be of cast-iron, bushed with brass, and to be secured by means of a flange recessed into and bolted to the cylinder head. They are to be fitted with metallic packing of approved design.

Arrangements must be made for the ready adjustment of the glands from the working platform while the engine is in motion, and for oiling the piston-rods and collecting the drip from the stuffing-boxes.

Main pistons.—Each cylinder is to be fitted with a composition piston having a double shell properly ribbed, and cast as light as consistent with strength. The pistons are to have cast-iron packing-rings fitting steam-tight and steel springs of approved design.

Piston-rods.— Each piston is to have one rod made of mild steel, polished.

The diameter of the high-pressure piston-rod is to be not less than 6 inches. The diameter of the low-pressure piston-rod is to be not less than 7 inches. Each piston-rod is to have a collar recessed into the lower side of the piston; the rod is to fit the piston accurately, and is to be secured by a composition nut accessible from the man-hole in the cylinder cover. The nut is to be secured by a set-screw. The upper end of the rod which projects through the cylinder cover is to be not less than 4 inches diameter for the high-pressure cylinder, and 4½ inches diameter for the low-pressure cylinder. The lower end of each piston-rod is to form the cross-head. It is to be U-shaped to receive the brasses for the cross-head journal, and to have at the front and back flanges to which the guide gibs are to be fitted.

The brasses are to be accurately fitted to their seats and bored and scraped to fit the cross-head journal. They are to be secured by a steel cap not less than 4¼ inches thick and 9 inches wide, finished all over, and held by two steel bolts not less than 4¼ inches in diameter, with finished nuts secured by set-screws, and turned all over to fit the bored holes of the cross-head. The thickness of the brasses at the crown is to be not less than 1½ inches for the upper one, and 1¾ inches for the lower one.

turned on each end of the journals, and the ends of the pins are to be turned slightly tapering, and accurately fitted, pressed in, and riveted to the webs of the cranks, which are to be bored and counterbored to receive them.

The webs of the cranks are to be 21 inches in diameter at pins and 9 inches deep.

The hubs of the cranks are to be 25 inches in diameter and 10½ inches deep.

The counterbalances are to have an extreme radius of 35 inches and a depth of 10½ inches.

The main journals are to be 13 inches in diameter. The length of the forward and two center journals is to be 20 inches each, and the length of the after journal is to be 24 inches.

The shaft is to extend 15 inches beyond the forward journal for the attachment of the eccentrics, and 36 inches beyond the after journal for the attachment of eccentrics and coupling.

The *brasses* for each journal of the crank-shaft are to be in two parts, to be cast hollow, properly stiffened by ribs, and fitted with pipes and cocks for the circulation of water through them. The brasses are to be bored in place and scraped to fit the journals accurately. The metal around the journals is to be not less than 1½ inches thick, and the water spaces 1½ inches deep. The brasses are to be set up metal to metal. They will be made circular at top and bottom, accurately turned to fit the bored seats in the pillow-blocks. Their sides will be flat, and they will be prevented from turning in their seats by cast-iron chocks of a length equal to that of the jaws of the blocks and of such a width and thickness that the lower

brass may be removed without raising the shaft. The brasses are to have flanges not less than 1½ inches thick, which are to be accurately fitted to the facings of the pillow-blocks.

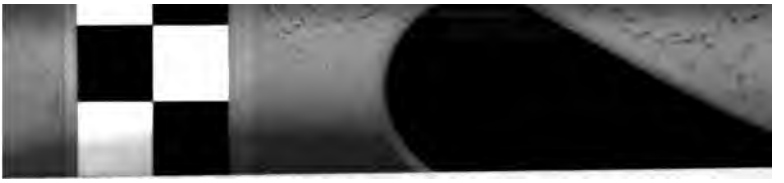
The *pillow-block caps* are to be of mild steel, finished all over, not less than 4½ inches thick at the crown and 3½ inches thick at the ends, and made with lugs fitting accurately over the jaws of the pillow-blocks, and bored to fit the journal brasses.

The forward and center pillow-block caps are to be secured by two steel bolts 4½ inches in diameter.

The after pillow-block cap is to be secured by four steel bolts 3¼ inches in diameter. The bolts are to be made of a square section at their lower part and with a T-head, and they are to be let into recesses formed in the pillow-block. The upper part of the bolts is to be turned. The nuts are to be finished all over; they are to be partly recessed into the pillow-block caps and secured by set-screws.

The *main pillow-blocks* are to be cast with, and form part of, the main engine bed-plate. The jaws of the blocks are to be not less than 5½ inches thick. They are to be provided with recesses for the cap-bolts, and are to be bored, faced, and planed for the brasses and caps.

The *bed-plate* is to be formed of four transverse box-frames, joining the main pillow-blocks to two longitudinal box-frames, all cast together in one piece. The box-frames are to consist of two vertical webs joined by vertical ribs and at the top by a solid horizontal web 10 inches wide, having at the bottom flanges not less than 2½ inches thick



running all around the circumference of the bed-plate inside and outside.

The top of the bed-plate is to be level with the horizontal plane passing through the axis of the crank-shaft. The depth of bed-plate to be 24 inches.

Four bosses, properly supported by ribs, will be cast on the bed-plate not less than eight inches deep, and bored, reamed, and faced to fit snugly the lower ends of the supporting columns of the cylinders.

Four facing strips are to be made on the top of the bed-plate, to correspond to the flanges on the supporting brackets of the condenser, which are to be secured to them.

The bottom flanges of the bed-plate are to be secured to the engine keelsons by wrought-iron bolts $1\frac{3}{4}$ inches in diameter, spaced not over 18 inches apart, on the outer and inner circumferences of the bed-plate.

The extreme length of the bed-plate over the bottom flanges to be 13 feet 6 inches.

The extreme width of the bed-plate over the bottom flanges to be 9 feet 7 inches.

The *stanchions* for the support of the cylinders are to be of the very best wrought-iron, finished, with collars forged to them. The diameter of the stanchions is to be not less than 4 inches at the upper end and 5 inches at the lower end. The collar at the lower end is to be not less than 9 inches in diameter and 2 inches thick; it is to be faced to bear on the boss cast on the bed-plate. Below the collar the end of the stanchion is to be turned cylindrical, 5 inches in diameter, to fit exactly the hole in the boss; it is to a have screw-thread at the end, and is to

be secured by a wrought-iron nut. The collar at the upper end is to be not less than 7 inches in diameter and 2 inches thick, and faced to fit the boss on the cylinder. Above the collar the end of the stanchion is to be turned cylindrical, 4 inches in diameter; it is to have a screw-thread at the end and is to be secured by a wrought-iron nut.

The *brackets* supporting the cylinders are to be made of the best cast-iron. Each bracket is to be secured to the cylinder by eight turned wrought-iron bolts, $1\frac{1}{2}$ inches in diameter, passing through faced flanges $2\frac{1}{2}$ inches thick and fitting snugly in reamed holes. Flanges to be heavily ribbed between bolt-holes.

Each bracket is to be secured to the condenser by twelve wrought-iron standing bolts, $1\frac{3}{8}$ inches in diameter, having finished wrought-iron nuts. The flanges to be not less than $2\frac{1}{2}$ inches thick and 23 inches wide, faced their whole width. The middle portion of the flanges to be raised two inches for a length of 22 inches. The corresponding recess in the flanges cast on the condenser to be planed out 2 inches longer at both ends to form seats for two finished steel keys which are to be snugly fitted and driven home solid.

The side of the bracket which carries the crosshead-guide plate is to be united to these flanges by solid webs properly ribbed.

A *crosshead-guide plate*, made of the best close-grained cast-iron as hard as it can be worked, is to be accurately fitted and firmly bolted to each bracket with wrought-iron bolts. The plate is to be not less than $1\frac{1}{2}$ inches thick, properly ribbed, and having ledges $1\frac{1}{2}$ inches high and $2\frac{1}{4}$

inches wide on both sides, between which the gibs are to be guided. The facing strips on the brackets to which the guide-plates are fitted are to be raised $1\frac{1}{2}$ inches, leaving a closed space behind the plate which is to serve as a water-back, being fitted with the proper pipes and valves for the purpose.

The *main slide valves* are to be made of the best cast-iron and as hard as can be worked. They are to be guided at their sides and back and are to be worked each by a single steel stem. The body of the valves to be not less than $\frac{3}{4}$ inch thick and well ribbed, and the faces on top and bottom to be $1\frac{3}{8}$ inches thick. The high-pressure slide valve to be balanced; it is to have double steam-ports each $1\frac{3}{4}$ inches wide by 28 inches long; the lap on the steam side to be $1\frac{5}{16}$ inches, and the travel of the valve to be $6\frac{1}{8}$ inches.

The low-pressure slide valve is to have double steam-ports, each $2\frac{7}{16}$ inches wide by 68 inches long; the lap on the steam side to be $1\frac{3}{16}$ inches, and the travel of the valve $8\frac{1}{2}$ inches.

The *cut-off valves* to be worked on the back of the main slide valves. They are to be of cast-iron, each to be operated by a single steel stem, made with a right and left-hand screw working in composition nuts fitted in suitable pockets in the valves; the upper end of the stem is to pass through the valve-chest and be guided within a brass bushing.

The *valve-stem* is secured by collars and nuts to a sliding block in which it must turn freely. The lower end of the stem is to be fitted with two steel feathers, and is to slide freely through a bevel-wheel gearing with another wheel,

which is fixed to a horizontal shaft and operated by means of a hand-wheel from the working platform. The bevel-wheels and hand-wheels are to be of brass, finished. The horizontal shaft is to be carried by a finished cast-iron stand with a brass cap, secured to the working platform. Pointers sliding on graduated scales are to be provided to indicate the points to which the cut-off valves are adjusted.

The *main slide-valve stem* is to be of mild steel, turned not less than 3¼ inches in diameter and polished. It is to be coupled directly to the link-block journal and is to be fitted with adjustable brasses.

The link-blocks are to have adjustable composition guides of ample surface.

Each *link* is to be formed of two solid bars of steel 4¼ inches deep and 2 inches thick, finished all over. They are to be curved to the proper radius and firmly united at the ends by turned steel bolts fitting snugly in reamed holes.

Links to have two pins welded to them at each end for the eccentric-rod journals, and at the center for the suspension-rod journals. Length of links between centers of eccentric-rod journals to be 30 inches; length of links over all to be 47½ inches.

Eccentric-rods to be made of mild steel, finished all over, 2 inches thick, 4 inches wide at the eccentric strap and 3 inches wide at the upper neck. They are to be dovetailed into and bolted to the eccentric straps with three wrought-iron bolts.

The eccentric-rods of the main valves are to have forked stub ends fitted with brasses, straps, gibs, and keys.

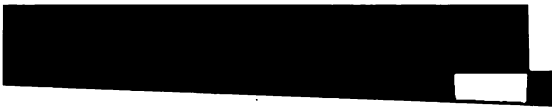
The eccentric-rods of the cut-off valves are to have single stub ends fitted with brasses, strap, gib, and key, and are to be coupled directly to a journal on the sliding block to which the valve-stem is secured.

The *eccentrics* are to be made of cast-iron, 5 inches thick through the boss, faced $4\frac{1}{2}$ inches at rim. They are to have a groove $\frac{1}{2}$-inch deep and $3\frac{3}{4}$ inches wide turned on their circumference, and are to be fitted with finished composition straps with adjustable chocks between lugs. They are to be held together by two finished wrought-iron bolts with finished heads and nuts.

The *reversing cylinder* is to be of cast-iron, smoothly bored to a diameter of 16 inches. It is to have a composition piston fitted with cast-iron packing-rings. It is to have a slide valve made of composition, which is to be worked by finished wrought-iron rods and levers from the working platform. The valve is also coupled by a rod and lever to an arm on the reversing shaft in such a manner that the motion of the piston tends always to reverse the valve. The exhaust pipe of the reversing cylinder is to lead to the condenser.

The piston-rod of the reversing cylinder is to be of wrought-iron, polished. It is coupled by means of a wrought-iron link, having adjustable brasses, to a finished wrought-iron arm 21 inches long keyed on the reversing shaft.

The *reversing shaft* is to be of mild steel turned to 5 inches diameter, with bosses turned 6 inches in diameter for keying on the arms. The shaft is to be supported by four cast-iron pillow-blocks provided with brasses and finished wrought-iron caps. Two of these pillow-blocks are to be



bolted to faced flanges on top of the condenser. Two of these pillow-blocks are to form parts of two brackets, which form also the valve-stem guides and support the cut-off gear. They are bolted to faced flanges cast on the under side of the cylinder casings.

The reversing shaft is to carry at each end a finished wrought-iron arm, having a steel pin forming two journals, secured at a distance of 42 inches from center of shaft.

Two finished wrought-iron suspension-rods are coupled to each arm and link. Eyes of supension-rods to be bushed with brass.

The *hand-reversing shaft* to be of wrought-iron, turned $3\frac{1}{2}$ inches in diameter.

It is to be supported by cast-iron pillow-blocks having brasses and finished wrought-iron caps, bolted one to the top of the condenser and one to the bottom of the low-pressure cylinder. A finished wrought-iron arm is to be keyed to the after end of the shaft, having a steel pin, secured by a wrought-iron nut and washer at a distance of 21 inches from the center of shaft. A finished wrought-iron rod provided with unhooking gear at one end connects this arm with the after arm of the main reversing shaft. A segmental wheel of cast-iron gun metal is secured to the hand reversing shaft, which gears with a wrought-iron screw operated by a large finished hand-wheel.

The *condenser-chest* is to be cast of the best iron, to be of a rectangular shape, strongly ribbed on the outside. It is to be 11 feet 6 inches long over facings of flanges for bonnets of water-chambers. It is to be placed with its longitudinal axis athwarthships at center of engines; the

facing of flanges for bonnets on starboard side to be 4 feet 9 inches from the longitudinal axis of engines.

The distance between facings of flanges for tube-plates to be 9 feet. The vacuum chamber is to be 37¼ inches wide and 7 feet 9½ inches high inside. The facings for tube-plates to be not less than 2 inches wide.

On the top of the condenser a nozzle is to be made corresponding to the opening of the exhaust passage of the low-pressure cylinder. The flange is to be not less than 2 inches thick and 4½ inches wide.

On both the forward and after sides of the condenser-chest two flanges are to be cast for securing the brackets supporting the cylinders and forming the cross-head guides.

These flanges are to be heavily ribbed.

A partition plate is to be secured in the condenser-chest above the tubes, with openings for distributing the steam over the length and width of the upper nest of tubes.

At the starboard end of condenser a channel-way is to be formed extending 8 inches below the bottom of the chest, and terminating, on the after side of the condenser, in a nozzle having a circular opening of 16 inches for connecting the pipe leading to the air-pump. On the forward side of the lower starboard water-chamber a circular nozzle, having an opening 15 inches in diameter, is to be made for connecting the pipe leading to the discharge of the circulating-pump. On the same side of the condenser-chest a channel-way is to be cast communicating at the top with the upper starboard water-chamber and terminating at the bottom, below the working platform, in a circular nozzle having an opening 15 inches in diameter, for connecting the pipe leading to the outboard-delivery valve.

At both ends two flanges are to be cast on the bottom of the condenser-chest for securing the pedestals which tie the condenser to the bed-plate.

Each pair of pedestals is to be made so as to leave between them a free passage to the center main bearings. The pedestals will be cast hollow, of rectangular section, 18 inches wide in a fore-and-aft direction and 15 inches wide in an athwartships direction; they will have faced flanges not less than $1\frac{3}{4}$ inches thick corresponding to flanges on bed-plate and condenser-chest, to which they will be securely bolted with wrought-iron bolts not less than $1\frac{1}{8}$ inches in diameter.

On the after side port-end of the condenser-chest will be cast a bracket for securing the steam reversing cylinder.

There will also be brackets for securing the pillow-blocks of reversing shafts.

Condenser tubes.—The condenser is to contain 3,068 seamless drawn-brass tubes of $\frac{3}{8}$-inch external diameter, No. 18 wire-gauge, heavily tinned inside and out, having an exposed condensing length of 9 feet and an extreme length of 9 feet $3\frac{1}{2}$ inches.

Tube-plates.—There are to be four tube-plates at each end, made of cast-iron $1\frac{1}{2}$ inches thick, and secured with wrought-iron standing bolts, 1 inch in diameter, to faced flanges. The tube-plates are to be bored to a diameter of $\frac{3}{8}$-inch for each tube, and counter-bored $\frac{7}{8}$-inch in diameter to a depth of $\frac{1}{8}$-inch and fitted with compressed paper grommets. The tubes are to be placed 1 inch apart between centers.

There is to be a brass supporting-plate $\frac{3}{4}$ inch thick, placed equidistant between the tube-plates and secured to

the top and bottom of the chest. This plate may be made in halves and is to be well tinned all over.

Air, circulating, and feed-pumps.—The air and circulating-pumps are to be combined direct-acting, of the Blake pattern.

The air-pump to have a diameter of 27 inches or less.

The circulating-pump to have a diameter of 26 inches. The steam cylinder to have a diameter of 24 inches. The stroke of pistons to be 24 inches.

The chests of the pumps and valve-chambers to be of cast-iron. The pump-barrels to be brass-lined; the lining extending the whole length of the cylinders to the heads. The pistons, valve-seats, and guards are to be of composition metal. The piston-rods to be made of phosphor bronze. All stuffing-boxes to have brass bushings and glands. The pistons of the pumps are to be packed with adjustable springs and fibrous packing. The pumps to have vulcanized carbolized rubber valves.

The valve-stems of the cylinders to be of steel.

The pistons, valves, and all working parts to be readily accessible for examination, adjustment, and repair.

The *air-pump suction* and *discharge* nozzles to be circular, 16 inches in diameter. The suction to be connected with condenser by a copper pipe having brass flanges properly riveted and brazed to it.

Care is to be taken in the arrangement of the suction valves and pipes that there is no tendency to intercept the free flow of vapor from the condenser to the valves by an accumulation of water in the suction-pipe or induction-chamber.

The air-pump discharge is to be connected to the fresh-water tank which forms the hot-well.

The *circulating-pump* is to have circular suction and discharge nozzles having a diameter of 15 inches, which are to be connected with the main injection valve-chest and lower water-chamber of the condenser, respectively, by copper pipes. The suction is also to be connected with a bilge injection valve and pipe. The discharge of the pump to have an air-chamber of ample capacity.

It is to have a pass-over valve, which is to be regulated by means of a screwed stem and hand-wheel, and allows the water to pass directly from the pump into the outboard delivery pipe.

The *exhaust-pipe* of the steam cylinder is to be of copper, and is to have two branches provided with screw stop-valves, one leading to the receiver and one leading to the top of the condenser.

The *feed-pumps* are to have a diameter of $5\frac{1}{2}$ inches; they are to be single-acting plunger-pumps, having a stroke of 24 inches, and are to be worked directly from the cross-head of the circulating-pump.

The barrel of the pumps, the plungers, valve-chests, seats, and guards are to be of brass in all their parts.

The valves to be of carbolized vulcanized rubber.

The pump barrels to be secured one on either side of the steam cylinder of the air and circulating pumps. The discharge of each pump to be fitted with a copper air-vessel of ample capacity.

Each pump to be connected with the hot-well by a copper suction-pipe.

Each pump to be fitted with a relief-valve, allowing the surplus water to return to the hot-well.

Both pumps to discharge into a common feed-pipe.

Stop-valves to be provided for closing communication between either pump and main feed-pipe and hot-well.

The *hot-well* is to be a wrought-iron tank placed as high as convenient on the starboard side of the vessel. It is to be connected by an overflow pipe containing a non-return valve with the outboard delivery. It is to have a pipe and cock for admitting to it water from the sea. It is to be fitted with a filtering arrangement of an approved form, which must be easily accessible for examination and cleaning. The feed-pump suction to draw the water from the filtering chambers.

The hot-well to be provided with a glass water-gauge fitted with guard and cocks.

All drain pipes of steam spaces are to be led to the hot-well.

The *bilge-pumps* are to have composition barrels, valve-chests, seats, and guards, hinged brass valve faced with rubber for suction, and vulcanized carbolized rubber valves for delivery. The stuffing-box to have an annular packing space 1 inch wide and 7 inches deep.

The bilge-pumps are to have a diameter of 8 inches and a stroke of 9 inches. They are to be worked by means of a link directly from an eccentric consisting of a cast-iron wheel with a composition strap. The pumps will be right and left, placed at an angle, one on each side of the keel. The pump-chests to be bolted to the after end of the main engine bed-plate.

The valve-chests to be provided with bonnets for the

ready examination of the valves; the delivery to have an air-vessel.

The suction and delivery pipes to be of copper 4 inches in diameter. A check-valve is to be placed in the delivery pipe of the pumps.

The *main injection-valve* is to be on the starboard side of the vessel, placed between frames 81 and 82, and at a distance of 6 feet 6 inches above the base-line of the ship measured to center of opening inside of hull.

The valve-chest is to be of cast-iron and to be fitted with a composition seat, and to inclose a composition valve with a gum face to cover an opening 15 inches in diameter. The valve is to be fitted with a composition screw-stem with stuffing-box and hand-wheel; the stem to turn independently of the valve.

The chest is to be attached to the ship in the most substantial manner, and to have a strainer outside of the ship with 1,200 holes of $\frac{3}{8}$-inch diameter.

The valve-chest is to have a nozzle having a circular opening 15 inches in diameter for connecting to the injection pipe.

The *outboard delivery* valve-chest is to be of cast-iron, and to have a composition seat with an opening 15 inches in diameter. It is to inclose a composition valve with a gum face. The stem is to be of composition, and to be fitted with an approved arrangement for opening and closing the valve from the working-platform.

The chest is to have a nozzle 12 inches in diameter and a flange for connecting the overflow of hot-well. The main delivery pipe of the condenser is to be of cop-

per 15 inches in diameter, and connected to a nozzle on the valve-chest.

The valve-chest is to be secured to the side of the ship, between frames 81 and 82, in the most substantial manner, over an opening having an area equal to that of a circle of 16 inches diameter.

A *sea-valve* having an opening of 10 inches diameter is to be placed on the port side of the vessel at after end of engine-room for connecting with the steam-pump. The chest is to be of cast-iron, with composition valve-seat. The valve is to be of composition, and fitted with a screw-stem and stuffing-box and hand wheel.

The chest is to be attached to the ship in the same manner as that of the main injection-valve. It is to have a strainer with 500 holes of $\frac{3}{8}$-inch diameter fitted over the opening outside the ship.

A *discharge-valve, 8 inches in diameter*, with cast-iron chest and composition valve and seats, is to be fitted to the port side of the vessel near the water-line, for connecting with the discharge pipes of the independent steam-pump and main bilge-pumps.

The *steam stop-valve* for the high-pressure cylinder is to have an opening of 13 inches diameter. It is to have a cast-iron chest, composition valve and seat, and to be operated by a screw-stem working in a composition nut supported by two finished wrought-iron studs. The stem to be fitted with a hand-wheel finished all over.

The *throttle-valve* is to be bolted to a nozzle cast on the chest of the steam stop-valve. It is to have a diameter of 14 inches and to have a composition chest. It is to be operated by a finished wrought-iron lever on the starboard side of the working-platform.

A *steam relief-valve*, having a diameter of 4 inches, is to be attached to the main steam-pipe in the engine-room. It is to be operated by a screw-stem and hand-wheel from the working-platform, and is to be connected with a copper pipe leading to the vacuum chamber of the condenser.

Indicator attachments, to be of brass, finished, are to be fitted to each end of each cylinder. Pipes to be not less than 1½ inches inside diameter with cocks of equal area of opening. Indicators to be easily accessible from the upper gallery. Indicator attachments are to be likewise fitted to the steam and pump-cylinders of the air and circulating pumps.

The *galleries* and *stairs* of engine-room are to be of cast-iron, and to have finished brass hand-rails 1½ inches diameter, supported by finished wrought-iron columns. Bottoms of columns are to be fitted and secured to bored sockets cast on the gallery and tread of stairs; the upper ends of columns to be fitted with finished brass sockets on the hand-rails.

The cylinders and covers, valve-chests and covers, and receiver, reversing cylinder, and circulating-pumps, and steam and exhaust pipes in engine-room are to be covered with asbestos board and hair felt and cased with black walnut, finished in oil, secured by finished brass hoops and brass screws.

Pipes too small to be cased to be covered with canvas outside the felt; canvas to be painted.

All jacket spaces are to be filled with steam of boiler pressure.

The *disengaging coupling* is to be made of cast-iron. To the end of the crank-shaft a fixed disk is to be secured,

having on its after face four segmental lugs 4 inches deep, with brass facings grooved into and bolted to them. The hub and disk to be reinforced by wrought-iron bands shrunk on them. The disk is to be shrunk on the shaft and secured by two steel keys 2 inches square in section, placed opposite each other. A suitable attachment is to be made to the disk for turning the engines by hand.

The sliding part of the coupling is to be bored and slotted to fit the forward end of the shafting and the feathers securing it. It is to consist of a disk having on its face four segmental lugs corresponding with those on the fixed disk, and fitted with hardened steel facing plates. In the hub a circular groove is to be turned to receive a loose wrought-iron collar. The hub and disk to be reinforced by wrought-iron bands shrunk on them. The sliding part of the coupling to be worked by tool-finished wrought-iron levers connected by links with a screw operated by a hand-wheel. [*See Addenda, No. 2.*]

The *line-shafting* is to be made of mild steel, turned all over, and made in three sections.

The *forward section* is to be about 27 feet 2 inches long. The end next to the engines is to be turned 13 inches in diameter, and fitted with two steel feathers $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches, placed opposite to each other, and dovetailed securely into the shaft for sliding clutch of disengaging coupling.

Thirteen thrust collars, 17 inches in diameter, the collars $1\frac{1}{4}$ inches thick, with spaces $1\frac{1}{2}$ inches wide between them, are to be turned on the shaft. The shaft between the collars to be 13 inches in diameter. The distance from forward end of shaft to center line, equidistant from outside collars, to be 66 inches.

A journal 13 inches diameter and 18 inches long to be fitted between thrust-collars and clutch coupling.

A journal, 13 inches in diameter and 18 inches long, to be turned on shaft near the after end, which is to have a coupling flange forged on. The remaining length of the shaft to be turned to a diameter of 12½ inches.

The *middle section* is to be about 26 feet 9 inches long; each end is to have a coupling flange forged on.

A journal, 13 inches in diameter and 18 inches long, is to be turned on the shaft near after end, also a journal for a spring-bearing, 13 inches in diameter and 12 inches long, near the middle of the shaft.

The remaining length of the shaft is to be 12½ inches in diameter.

The *after section* is to be about 27 feet 5 inches long. The forward end is to have a coupling flange forged on. The shaft is to be turned to a diameter of 13 inches and covered from the coupling to 3 inches inside the hub of the propeller with a brass casing ½ inch thick; the journals to be polished. The several sections of the casing to overlap and fit perfectly water-tight. The after end of the shaft to be turned tapering to fit accurately the hub of the propeller; it is to be slotted for two keys, placed opposite to each other lengthwise the shaft, and a cross-key.

The *couplings* of the several sections of the line-shafting are to be forged on. They are to have faced flanges 4 inches thick and 26 inches in diameter, united by six 3-inch steel bolts turned to fit bored holes in flanges accurately and secured by tool-finished nuts. There is to

be also a steel cross-key, $1\frac{3}{4}$ inches thick and $2\frac{1}{2}$ inches wide, accurately fitting corresponding grooves in both couplings.

The *thrust-bearing pillow-block* is to be fitted with a cast-iron cap made with an oil-cup on the top, in which Winter's lubricating arrangement is to be used. The flange of the cap is to be made with lugs, planed and fitted in corresponding recesses in the upper flange of the block, to which it is to be secured by not less than six wrought-iron bolts $1\frac{7}{8}$ inches in diameter.

The block and cap to be faced at the ends and bored to a diameter of 17 inches, and to have 12 annular grooves turned $1\frac{1}{2}$ inches wide and 2 inches deep and $1\frac{1}{4}$ inches apart, with composition rings accurately fitting the grooves. The rings are to be divided in the horizontal plane passing through the axis of the shaft, and prevented from turning by hard-wood liners.

The bottom flange of the thrust-block is to be planed and fitted and firmly bolted to a sole-plate, and secured in position by two steel keys bearing against interlocking projections of the pillow-block flange and sole-plate.

The *sole-plate* is to be of cast-iron, with projecting lugs at each end, planed on top and bottom, and to be firmly bolted to the wrought-iron foundation built up in the ship, with a wood lining between them.

The *pillow-blocks* for the *forward* and *middle sections* of *line-shafting* are to be of cast-iron, 18 inches long over facings, with a lower brass $1\frac{1}{4}$ inches thick, and with a cast-iron cap having an oil-cup cast upon it. The brass and cap to be smoothly bored to fit the shaft journals. The blocks are to be planed on the bottom and firmly

bolted to the sole-plates, which are to be secured to the wrought-iron foundation built in the ship.

The *spring bearing* of the middle section of line-shafting is to have a cast-iron pedestal holding a lower brass, which is to fit the journal of the shaft and to be adjustable. The pedestal is to be planed on the bottom and firmly bolted to a wrought-iron foundation built up in the ship.

The *stern bearing* is to consist of a brass bushing made in halves and fitted with lignumvitæ staves inserted in longitudinal grooves, and bored to a diameter of 14 inches. The bushing is to be 6 feet long and turned to a diameter of 17 inches, the stern-post and stern-pipe being bored correspondingly to receive it. The stern bearing is to have a flange $1\frac{1}{2}$ inches thick and 27 inches in diameter, and is to be secured to the boss of the stern-post by composition bolts not less than $1\frac{1}{8}$ inches diameter and making a water-tight joint.

A similar bearing, 48 inches long, but of the same dimensions otherwise, is to be placed at the inboard end of the stern-pipe.

The stuffing-box is to be made of cast-iron in halves, bolted together with wrought-iron bolts. It is to have a branch-pipe fitted with a cock for the circulation of water through the stern-pipe bearings. The stuffing-box is to have an annular packing space not less than 1 inch wide and 13 inches deep, and is to be fitted with a brass follower made in halves.

The *screw-propeller* is to be right-handed, 14 feet 3 inches in diameter, and having a mean pitch of 21 feet 4 inches. It is to be cast of steel with four adjustable blades, having a width of 30 inches in a fore-and-aft direction, and curving back from the stern-post.

The hub is to be bored its whole length to fit the taper on the shaft accurately, the casing of the shaft to enter the hub 3 inches. It is to be secured to the shaft by two longitudinal keys placed opposite each other, and by a cross-key placed 5 inches from end of shaft. The hub is to project beyond the shaft, and is to be covered water-tight with a cap bolted to the end of hub. Cross-keys likewise to be covered water-tight by caps. The edges of the blades are to be made sharp and the surfaces smooth.

The design of the screw will be such as the Naval Advisory Board decide upon to obtain the best results.

Boilers and Attachments.—The *boilers* are to be constructed of open-hearth steel, subject to the tests prescribed by the Advisory Board. All plates to be planed at the edges, and to be as large as can be procured, making the seams as few as possible, according to drawing. All seams to be calked perfectly tight. All seams not in contact with the fire to be double-riveted. Circumferential seam of upper portion of front heads of double-end boilers to be treble-riveted. All holes to be drilled, or punched $\frac{5}{16}$ inch small in diameter and drilled to size.

Each *single-end boiler* to be 11 feet external diameter and 9 feet 6 inches long. It is to contain two cylindrical furnaces of 40 inches internal diameter.

Each *double-end boiler* to be 11 feet external diameter, 18 feet 3 inches long. Ends to slope back at the top as shown in drawing. It is to contain at each end two furnaces of 40 inches internal diameter.

Shell to be made of plates $\frac{3}{4}$ inch thick. Longitudinal joints to have inside and outside straps $\frac{1}{2}$ inch thick and $9\frac{1}{2}$ inches wide, double-riveted each side of seam.

Circumferential joints to be made of a single outside butt-strap $\frac{3}{4}$ inch thick, $9\frac{1}{2}$ inches wide, double-riveted each side of seam.

Each *furnace* to be formed of three truly cylindrical sections 40 inches internal diameter. Each section to be formed of a single sheet $\frac{1}{2}$ inch thick, butted and strapped. Strap is to be placed inside below the grate, at one side, placed so as to bring the seams of the three sections in line. Furnace tubes to be flanged at the ends and riveted to each other with a welt $\frac{1}{2}$ inch thick between them. Furnace tubes to project 5 inches beyond front of boilers, to be single-riveted throughout. Stay tubes to have steel ferrules on both ends expanded and riveted over.

Back connections to be not less than 22 inches deep and to be separate for each furnace; top to be curved as shown in drawing. To be made of $\frac{9}{16}$-inch plates, lap-jointed, single-riveted.

If it is decided to leave out the whole or part of the water-legs in the back-connections a perforated brick-bridge wall and division is to be fitted instead.

Back Tube-sheets to be $\frac{9}{16}$ inch thick. Front tube-sheets to be $\frac{3}{4}$ inch thick; each tube-sheet to be accurately drilled for 188 tubes.

The *tubes* to be spaced $3\frac{3}{4}$ inches between centers, horizontally and vertically. Tubes to be of drawn brass $2\frac{3}{4}$ inches external diameter, No. 11 Birmingham wire-gauge thick, 6 feet 10 inches long from outside to outside of tube-plates.

The upper parts of heads to be braced by rods $1\frac{3}{4}$ inches thick, placed 12 inches between centers. The ends of rods to be made with jaws and coupled to stay-plates at each end by a wrought-iron bolt $1\frac{1}{2}$ inches in diameter.

Stay-plates to be $\frac{3}{4}$ inch thick, secured to the boiler by two angle-irons $2\frac{1}{2}$ by $2\frac{1}{2}$ by $\frac{1}{2}$ inch. Stay-plates to be made with lugs, leaving room for removal of braces.

Braces of double-end boilers to be made in two lengths, coupled in the middle by bolts and nuts, and each vertical row to be supported by a common hanger attached to the shell. Top of back connection of single-end boilers to be supported from stay-plates on back head. Tops of opposite back connections of double-end boilers to be braced to each other.

Sides and back of back connections to be stayed with stay-bolts, spaced not over 7 inches apart in vertical and horizontal rows. Stay-bolts to be screwed in both sheets and riveted over at the ends. Screwed ends of bolts to be $1\frac{1}{4}$ inches in diameter, having 12 threads to the inch; body of bolts to be turned $1\frac{1}{8}$ inches in diameter.

Fronts of back connections opposite man-holes in front heads to be stayed by domes $\frac{9}{16}$ inch thick, riveted over circular openings as shown in drawing.

Each *grate* to be 40 inches wide and 6 feet 9 inches long.

Man-holes to be closed with wrought-iron plates and secured with double wrought-iron bars and bolts.

The *front connections* and *uptakes* are to be made with double shells of wrought-iron, properly stayed. Inner shell to be made of iron weighing 5 lbs. per square foot; outer shell to be made of iron weighing 3 lbs. per square foot. All joints to be tight. The front connection of each nest of tubes corresponding to a furnace is to be separated by a division plate fitted tight up to the seat of the damper.

Dampers.—A separate damper is to be fitted for the uptake of each furnace, which is to be provided with levers for working it readily from the fire-room floor. Dampers to ash pits to be worked from the fire-rooms.

Front connection doors to be made of wrought-iron, double shell, and fitted with the proper hinges and catches. Doors to fit tight.

Furnace fronts to be made with a cast-iron frame, covered with wrought-iron plates $\frac{3}{8}$ inch thick; outside plates to have air-holes provided with a close-fitting register; inside plates to be perforated with $\frac{1}{8}$-inch holes, closely spaced.

Furnace-doors to be made of wrought-iron with double shell $\frac{1}{4}$ inch thick. Front plates to have openings provided with a close-fitting register. Back plate to be perforated with closely spaced $\frac{1}{8}$-inch holes. Hinges and latches to be of wrought-iron. Doors to be fitted tight to furnace fronts.

Ash-pit doors to be made of wrought-iron, to be fitted to close the ash-pit tight, and to be made so as to be readily taken off and hung up on hooks provided on the uptake doors.

The *smoke-pipe* is to be 7 feet 3 inches in diameter inside and 39 feet high above the top of the steam-drum. The lower lengths are to be of No. 6 and the upper ones of No. 8 iron, Birmingham gauge. The pipe is to be made with the proper bands, butt-straps, eyes, stays, and supports for covers.

Steam-drum.—There is to be one vertical steam-drum, 7 feet 6 inches in diameter and 8 feet 6 inches high. It is to be placed on the center line of the vessel, its center 6 inches abaft the after front of the forward boilers. It is

to be made of the open hearth steel. Shell to be $\frac{7}{8}$ inch thick, butt-jointed, with inside and outside covers, double-riveted; heads to be $1\frac{1}{16}$ inch thick. It is to be traversed by six lap-welded flues 18 inches in diameter. Heads to be securely braced for a working pressure of 100 lbs. per square inch.

Man-holes are to be provided in the lower head to make the interior accessible in every part.

Smoke-jacket.—The drum is to be surrounded by a cylindrical smoke-jacket having an internal diameter of 10 feet 3 inches; the annular space between the jacket and drum to communicate with the uptake below and the smoke-pipe above.

The smoke-jacket is to be made with a double shell properly stayed with socket rivets, inclosing an annular space $1\frac{1}{2}$ inches wide. The inner and outer shells to be made of wrought-iron plates weighing 5 pounds and 3 pounds per square foot, respectively.

Dry-pipes.—Each boiler is to have an iron dry-pipe thoroughly tinned; the pipe to be placed as high as possible, the top to have holes $\frac{3}{8}$ inch in diameter, drilled equally distant, the aggregate area of these holes to be double the cross-section of the pipe.

The dry-pipe of each single-end boiler to have an internal diameter of 7 inches.

The dry-pipe of each double-end boiler to have an internal diameter of $9\frac{1}{2}$ inches.

The dry-pipe to communicate with a flanged mild-steel nozzle riveted to the outside of the boiler. An iron casting bolted to this nozzle is to have proper nozzles and flanges for securing the safety-valve, main stop-valve, and auxiliary stop-valve of each boiler.

Safety-valve.—Each boiler and the steam-drum is to have a spring safety-valve of the Ashcroft pattern, set for a pressure of steam of 90 pounds per square inch, and provided with proper gear for raising the valve from the fire-room floor The chests to be of cast-iron, the valves of composition, and the seats of nickel. The valves to be connected to copper escape-pipes leading up alongside the chimney. The safety-valve of each single-end boiler to have a diameter of 4½ inches. The safety-valve of each double-end boiler and of the steam-drum to have a diameter of 5½ inches. The safety-valve of the steam-drum to be secured to a flanged wrought-iron pipe passing through the uptake near the upper end. Escape-pipe to be fitted with muffler and made with a bell-mouthed top.

Boiler stop-valves.—Each boiler is to have a stop-valve having a cast-iron chest, composition valves and seats, and screw-stems made to turn independently of the valves and work in a composition nut supported by wrought-iron studs on the covers. The valve to be operated by a hand-wheel 15 inches in diameter, the rim of which is to be inclosed in asbestos covered with stitched canvas.

The stop-valve of each single-end boiler is to be 6 inches in diameter.

The stop-valve of each double-end boiler is to be 8½ inches in diameter.

The stop-valve of each double-end boiler is to be connected by a copper pipe 8½ inches in diameter of No. 12, Birmingham wire-gauge, to flanged wrought-iron pipes passing through the smoke-jacket and riveted to the shell of the drum.

The stop-valves of single-end boilers are to be connected

by a common pipe of the same dimensions to the drum; the two branches being copper pipes 6 inches in diameter No. 14, Birmingham wire-gauge. All copper pipes to have composition flanges properly riveted and brazed on.

Auxiliary stop-valves.—Each boiler is to have an auxiliary stop-valve 4½ inches in diameter, otherwise of the same construction as the boiler stop-valves.

The several auxiliary stop-valves to be connected by a system of pipes having an internal diameter of 4½ inches. These pipes to be of copper No. 16, Birmingham wire-gauge, with composition flanges.

Branches of proper size are to be led to the blower engines, steam-pumps, and distiller, steering, and electric-light engines, and fitted with the proper stop-valves.

Drain-cocks and drip-pipes to be provided for all valve-chambers, steam, and escape-pipes.

Main stop-valve.—The main stop-valve is to have a diameter of 14 inches, and is to be of the same construction as the boiler stop-valves. It is to be secured to a flanged wrought-iron pipe passing through the smoke-jacket and riveted to the shell of the steam-drum, and is to communicate with an internal pipe so as to draw the steam from the top of the drum.

Main steam-pipe.—The steam-pipe is to be of copper, having a diameter of 14 inches, No. 7 Birmingham wire-gauge thickness. The several sections to be united by composition flanges properly riveted and brazed to the pipes. All the steam-pipes to be heavily tinned inside and outside.

Feed-valves.—Each boiler is to have a check feed-valve inclosed in a chest having two stop-valves of the same diameter to shut off communication between check-valve

and boiler and feed-pipe, respectively. Valves and chests to be of composition. Single-end boilers to have feed-valves of 2¼ inches diameter. Double-end boilers to have feed-valves of 3 inches diameter.

Blow-valves.—Each boiler to have a bottom blow-valve of 2½ inches diameter, also a surface blow-valve of 2 inches diameter, all connected by suitable pipes to the sea-valves on the ship. Valves and chests to be of composition.

Feed and blow-pipes.—The main feed and blow-pipes to be made in sections not exceeding 12 feet in length; to be made of drawn brass tubes, 4 inches inside diameter, of No. 8 Birmingham wire-gauge. Branches to be proportionately smaller. The pipes to be fitted with composition flanges and elbows. Interior of feed-pipes to be well tinned.

The blow pipes are to be connected to both sea-valves in after fire-room, and are to have screw stop-valves arranged so that communication with either may be shut off and that the boilers may be pumped out by the steam-pump through the blow-pipes.

Sea-valves.—There are to be two sea-valves in the after fire-room, one to be placed between frames Nos. 64 and 63 on port side, and one to be placed between frames Nos. 64 and 65 on starboard side of vessel, and 12 feet 2 inches from the keel.

The valves are to have a diameter of 4 inches; they are to be made of cast-iron, the valves and seats of composition, and they are to be fitted with screw-stems, stuffing-boxes, and hand-wheels. The valve on the port side is to have a strainer on the outside of the hull, and is to be used ordinarily as the steam-pump suction.

Nozzles of proper size for blow-pipes, steam-pumps, and ash-hose to be provided.

A *sea-valve* 10 inches in diameter is to be placed in the forward fire-room. The chest to be of cast-iron, the valve and seat of composition, to be fitted with screw-stem, stuffing-box, and hand-wheel; a strainer to be fitted to bottom of vessel. Nozzles of proper size for steam-pumps and ash-hose to be provided.

Gauge-Cocks.—A combination gauge, including a glass tube of 18 inches exposed length, four cocks placed 6 inches apart; also drip-pan and pipe, is to be placed on the front of each boiler, the double-end boilers to have one at either end. The lowest cock to line with the bottom of glass tube and placed to show the level of the water at the highest heating surface.

Salinometers.—There is to be a Fithian salinometer-pot fitted to each boiler so as to be easily accessible.

Steam-Whistle.—A large finished steam-whistle of brass is to be conveniently placed above deck, with pipe and cock connecting to steam-drum.

Floor Plates.—Fire-rooms to be floored with wrought-iron plates having corrugations and proper ledges, and being easily removable and properly supported.

Cast-iron water-ways to be laid in front of the boilers.

Galleries formed of wrought-iron bars to be fitted at the level of the berth-deck, with stairs leading to them to make the blowers and stop-valves in the after fire-room accessible. A gallery formed of cast-iron plates properly supported to be fitted in the forward fire-room at the level of the berth-deck. Winding stairs to lead from this gallery to the fire-room floor; stairs to lead to the upper deck.

Iron railings to be provided for all galleries and stairs in fire-rooms.

Ventilators.—Two ventilators, 24 inches in diameter, to be fitted in forward fire-room, arranged for ash-hoisting. Two ventilators, 24 inches in diameter, and two ventilators 22 inches in diameter, to be fitted in after fire-room—the latter to be arranged for ash-hoisting. Ventilators to have movable hoods capable of being worked from the fire-room by means of brass gearing, and will be of wrought-iron. They must be provided with an accurately fitting door for closing them when an air pressure is to be maintained in the fire-rooms, and will be made and fitted as shown on hull drawings and provided for in the specifications.

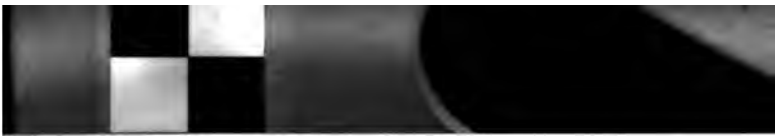
Boilers to be secured in saddles by turned wrought-iron bolts passing through the shell and fitting snugly in reamed holes.

Before being placed in the vessel all the boilers are to be subjected to a water-pressure of 150 pounds per square inch, and to be made perfectly tight.

Boilers to be painted inside and out with two coats of brown zinc paint. After the boilers are in the vessel the shell is to be covered with hair felt 1½ inches thick, securely sewed upon canvas, and this is to be covered with sheet-lead with soldered water-tight joints; or, if required, a covering of galvanized iron, with an air-space, may be substituted, on the approval of the Naval Advisory Board.

MISCELLANEOUS ARTICLES.

Store-rooms and tanks to be placed as directed. The former to be suitably fitted with shelves, lockers, doors, &c., and well painted. The waste locker to be fitted with a pipe for flooding it.



Each bilge-receiving pipe to be fitted with a *Macomb strainer* of proper size, placed in an easily accessible position.

The crank-shaft journals are each to have three large finished brass oil-cups of approved design, with tubular wick-holders adjustable in oil-tubes. Each crank-pin journal is to have two similarly fitted large finished brass automatic oil-cups of approved design. All other engine journals and movable parts, and especially the cross-head slides, are to have finished brass oil-cups of suitable size. Each cylinder and each cylinder valve-chest is to have two properly finished brass grease-cocks, with globe upper cock, and cup. Those for the high-pressure cylinders are to be operated as pumps from the engine. Where necessary, sheet-brass drip-pans are to be attached.

Water-pipes of copper, 3 inches in diameter, are to lead from each stern-pipe stuffing-box cock to engine-room and be fitted with hose attachments for the thrust and line shaft-bearings; also branch pipes for all water brasses; the pipes for supplying the crank-shaft journals, crank-pins, and cross-head guides are to form hand-rails opposite the cranks. There are to be suitable hose-pipes properly attached to the sea-valves for wetting down ashes.

All journals and moving parts of iron are to be run upon brass boxes.

All holes through the ship are to be fitted to close watertight, and covered by a cock or valve on the inside.

Hose.—Five hundred feet of naval standard $2\frac{1}{2}$ inch, 4-ply, carbolized rubber hose, in lengths of fifty and twenty-five feet, are to be provided. Each length is to be fitted with couplings made to correspond with those used in the Navy;

reels sufficiently large to contain 300 feet are to be placed in convenient positions. Three 1-inch nozzles and six spanners will also be furnished. Couplings of naval standard, fitted for fire-hose, and furnished with caps and spanners, are to be placed as permanent fixtures through water-tight bulkheads in such a manner that the doors in said bulkheads need not be opened for passage of hose.

Wrought-iron eye-bolts and traveler-bars are to be properly located and secured wherever required for lifting different parts of the machinery, and particularly the covers of valve-chests, the covers of steam-cylinders, and the caps of the thrust-block and of the pillow-blocks of the line-shaft journals.

The shaft-alley, engine, fire and store-rooms are to be furnished with large fixed swivel lamps, well secured to bulkheads, in sufficient number and of approved pattern.

Three *bill-frames* of black walnut, with glass fronts, will be provided for watch, cleaning, and fire stations, with provision for substituting names; to be placed in conspicuous positions on engine-room bulkheads.

Painting.—All engine work not finished is to be primed with two coats of brown zinc and oil; when placed in the vessel to be painted with two coats of chrome green and oil. The line-shafting is to be painted, after being placed in the vessel, with two coats of white lead and oil. After the boilers are placed in the vessel the fronts are to be painted with two coats of lampblack and oil. All steam-pipes not cased with wood will be painted white, exhaust-pipes green, and water-pipes leading from pumps lead color.

All thread on bolts to correspond with Navy standard.

Quality of materials and workmanship.—All the mate-

rials used in the construction of the machinery are to be of the best quality. The iron castings to be made of the best pig-iron, not scrap. The steel forgings to have an ultimate tenacity of not less than 65,000 lbs. per square inch, and an ultimate elongation of not less than 23 per cent. in an original length of 8 inches. The brass to be of pure copper and tin from new materials. For all journal boxes and guide-gibs the composition to be by weight, six parts of copper, one part of tin, and one-fourth of one part of zinc. For other brass-work the composition to be eighty-eight parts copper, ten parts of tin, and two parts of zinc.

The iron castings to be smooth skinned and true to form, and before being painted to be well cleansed of sand and scale. Brass castings to be smooth and true to form. No unsound forgings or imperfect castings to be used, whether the imperfection relates to strength or appearance.

All steam, exhaust, and other pipes leading to and from auxiliary engines, distillers, and pumps are to be of sufficient size, with provision for expansion where necessary. All copper pipes to be brazed, and to have brass flanges riveted on, calked on both sides, and brazed. All pipes not otherwise specified to be of copper and tinned. All nuts on rough castings to set on facings raised above the surface. The work to be in every respect of the first quality, and executed in a workmanlike and substantial manner. All the flanges to be faced and grooved. No standing or other bolt-holes to be drilled through into vacuum spaces. All bolt-holes to be reamed, and the body of the bolt finished to fit them snugly.

All brasses to fit loosely between collars of shafting. All cocks communicating with vacuum spaces to have bot-

tom of shell cast in, and to have the plug packed by means of a stuffing-box and follower. All nuts on moving parts and on pillow-blocks to be thoroughly secured with keepers, pins, or set-screws. All brass boxes for journals to be properly channeled for the distribution of oil. All flanges coupled together to be faced and edges made fair with each other.

All patent fees to be paid by the builders, and no extra bills presented or additional compensation claimed. If, after the completion of machinery, there shall be at any time discovered in it any departure from the specifications, tending to cheapen its construction by lessening the thickness of metal or by substituting iron for brass, or tool-finish for finish, or brass in which zinc is a larger element, or by omission of finish, or by lessening the diameters or areas of pipes, valves, &c., the injury to the Government thus received may be estimated and determined by the Advisory Board under directions of the Secretary of the Navy, and the amount recovered from the parties of the first part, who hereby bind themselves to abide by such determination.

A complete set of *drawings* in detail is to be furnished. [*See Addenda, No. 3.*]

A suitable office, properly fitted and heated, for use of the inspector and his assistants during the building of the machinery is to be furnished by the contractor.

Duplicate Pieces.—All duplicate pieces to be finished, fitted and ready for putting in. They are to be as follows:

Two receiving valves for main bilge-pumps.

Two sets of carbolized gum-valves and springs for all steam-pumps.

One set of follower-bolts and nuts and steel springs for

each steam-piston, and one set for air-pump and circulating pump-pistons.

One set of metallic packing for each cylinder and valve stem stuffing-box.

One set of brasses for each main journal of the crank-shaft.

One set of brasses for each crank-pin.

One set of brasses for each thrust-bearing.

One set of brasses for each line-shaft pillow-block.

One set of brasses for each cross-head journal.

Two complete sets of brass slippers for cross-head guides.

One block and gibs for each Stephenson link.

One set of brasses for each eccentric-rod connection.

Two crank-pin oil-cups, with all appendages.

Three main-journal oil-cups.

Two hundred tubes for condenser packed in boxes.

One thousand grommets for condenser-tubes, packed in tin boxes.

Four Macomb bilge-strainers.

One spare propeller blade of steel, with bolts.

All duplicate pieces not of brass to be painted with three coats of white lead and oil and well lashed in tarred canvas, with name painted on outside. Brass pieces to be painted with one coat of white lead and oil. All duplicates plainly stamped for what purpose intended.

Oil-tanks, Cans, &c.—Four oil-tanks of iron $\frac{1}{8}$ inch thick, containing in the aggregate 1,500 gallons, to be well secured in engine-room, with facilities for filling from deck, and emptying, and to be strengthened by internal stays or otherwise. Each to have a man-hole on top and a brass cock 1 inch in diameter in bottom, and all connected with a pump.

Two copper oil-tanks to contain 10 gallons each, with

lids and drip-pans, to be placed permanently in the engine-room in a convenient position, and to have a locked brass cock on each.

One iron tallow-tank to contain five hundred pounds, with man-holes and hinged plate on top.

Two brass syringes.

Two brass tallow-kettles.

Four brass drip-pans for cans.

Two sets of copper measures, four in number—from one pint to one gallon.

Eighteen small brass injection feeders.

Eighteen brass oil-cans for feeders.

Instruments.—Four Tabor's indicators of standard size; two fitted for a scale of 40 lbs. to the inch and two for a scale of 20 lbs. to the inch, with proper attachments of finished brass to be fitted to each end of each cylinder. Pipes from indicator to cylinder, 1½ inches inside diameter, with cocks of equal area of opening.

Indicators to be made easily accessible, and the motion to be reduced by levers.

Two sets of instruments, with proper attachments, to be supported each in a brass case, as follows:

One Lane's improved spring steam-gauge.

One Lane's improved spring compound gauge.

One spring vacuum gauge.

One counter, with positive motion.

Faces of gauges to be 8½ inches in diameter.

One eight-day clock, placed independent of the other instruments.

One mercurial vacuum gauge for condenser, attached immediately to it.

Tools.—One hydraulic jack of ten tons capacity.

Four hydraulic-jacks of seven tons capacity each.

Two screw-jacks.

Four sets of iron blocks and falls, double purchase, for lifting parts of machinery, and arranged for eye-bolts.

One differential pulley with a capacity of three tons.

Six pinch-bars.

Four iron sledges, assorted sizes.

Eight riveting-hammers, assorted.

Six copper hammers.

Four copper sledges.

Two 6-inch vises.

One hand-vise.

Twelve dozen files, assorted.

Three dozen file-handles.

Twelve chipping-hammers.

Thirty-six cape-chisels.

Thirty-six cold-chisels.

Six calking-tools..

Two sets of roller expanding tools for boiler tubes.

Twelve scaling-hammers, assorted.

Eighteen scaling-bars.

Twenty-four brushes for sweeping tubes, and six handled rods fitted to them.

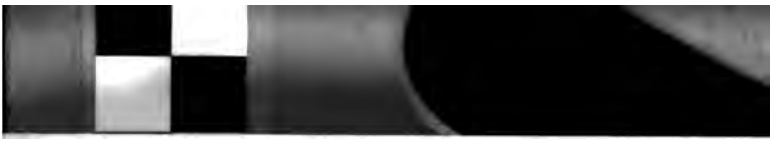
One steam-jet tube-cleaner, with hose attachment.

Two complete sets of fire-irons.

Lazy-bars for each boiler, fitted in place.

Two sets of wrenches complete, for engine, fitted to all the nuts, finished and marked for same, and fitted in walnut racks.

Twelve monkey-wrenches, assorted.



Wrenches for all nuts of bolts of 2 inches in diameter and over to be box-wrenches, and fitted in convenient rack.

One plate with taps and dies.

One set stocks with taps and dies from $\frac{3}{8}$ to $1\frac{1}{2}$ inches; threads of Navy standard, and similar to those used on engine.

One drill-standard.

One crank drill-brace.

Three ratchet drill-stocks of assorted lengths.

Twenty-four drills of assorted sizes and lengths, shanks to fit brace and stocks.

Three reamers, assorted.

Two center-punches.

Two pairs of compasses.

Four pairs of calipers, assorted sizes.

One steel square.

Six rules, two-fold, two feet.

One hack-saw, six blades.

Six axes, handled.

Two hatchets, handled.

One portable forge with blacksmith's tools, complete.

One tinman's forge, two soldering-irons, and two shears.

One iron ladle.

Twenty-four ship-scrapers, of steel.

Forty oak water-buckets, bound with brass, painted white inside and green outside, and branded "Engineer Department."

Ten ash-buckets, painted with three coats of brown zinc and oil.

Ten coal-buckets, painted with three coats of brown zinc and oil.

Six heavy coaling bags.
Thirty-six steel shovels.
One warehouse truck.
Two spring-balances.
One Fairbank scale of 20 pounds capacity.
One beam-scale of 300 pounds capacity.
Twelve log-slates, hinged, and seventy-five slate pencils.

ADDENDA.

No. 1. If in the course of construction of the machinery it be deemed advisable to use a duplex steam-pump for boiler feeding, it shall be put in by the contractor, without additional cost to the Government, in lieu of the feed-pumps attached to the air and circulating pumps.

No. 2. A steel friction-band with suitable gear is to be fitted for securing the propeller shaft when the engine is uncoupled.

No. 3. Working drawings of all parts of the machinery have to be submitted to and approved by the Naval Advisory Board before the work on them is taken in hand.

All parts of the machinery are to be carefully weighed when finished, and a record of such weights in detail is to be kept and transmitted to the Naval Advisory Board through the Inspector, who will be required to certify to its correctness.

No. 4. Any change in the valve-gear or any other details that may appear advisable may be made, provided the same does not alter the general design and is approved by the Naval Advisory Board.

TESTS OF STEEL FOR CRUISERS.

INSTRUCTIONS TO INSPECTORS.

NAVY DEPARTMENT,
NAVAL ADVISORY BOARD,
June 18, 1883.

The following rules are prescribed in order to insure the fulfillment of the clause of the act of Congress of August 5th, 1882. "Such vessels * * * to be constructed of steel, of domestic manufacture, having as near as may be, a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum:"

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle, supplied for these vessels, to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company. 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed the required inspection and tests, have been accepted by the Inspector, and have been stamped with the maker's brand.

In case of small articles passed in bulk, the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into the vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

SHIP-PLATES.

III. In every lot of 20 plates test pieces to be cut from two plates taken at random; two test pieces being cut from each plate, one in the direction of the rolling, and one at right angles to it, shaped according to the annexed sketch. These test pieces shall in no case be annealed.

The test pieces to be submitted to a direct tensile stress until they break, and in a machine of approved character.

The initial stress to be as near the elastic limit as possible; which limit is to be carefully determined by the Inspector in a special series of tests. The first load to be kept in continuous action for five minutes. Additional loads to be then added at intervals of time as nearly as possible equal, and separated by half a minute; the loads to produce a strain of 5,000 pounds per square inch of original section of the test piece until the stress is about 50,000 pounds per square inch of original section, when the additional loads should be in increments not exceeding 1,000 pounds.

An observation to be made of the corresponding elongation measured upon the original length of eight inches.

The final elongation to be that obtained at rupture. The loads applied shall never be calculated from the indications of the pressure gauge if a hydraulic press be used.

CONDITIONS OF ACCEPTANCE.

In order to be accepted the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in eight inches of not less than 23 per cent.

Lots of material which show a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per cent

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, 4 (called Test I), falls below either of the required limits, the plates from which pieces 1, 2, 3, 4 were cut shall be reected, and Test II made, consisting of pieces 5 and 6, cut from a third plate; if the mean of the results of these two falls below either of the above limits, the entire lot shall be rejected. If it be successful, Test III, or the mean of pieces 7 and 8, cut from a fourth plate, shall decide.

If in any of Tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the plate from which it was cut shall be rejected, and that test considered to have failed regardless of its average.